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Weight gain, overweight and obesity: determinants and health outcomes from the Australian Longitudinal Study on Women's Health.

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Abstract

Recent estimates suggest that 35.3% of adult Australians are overweight and a further 27.5% are obese. The Australian Longitudinal Study on Women's Health (ALSWH) is a prospective study of women's health that commenced in Australia in 1996. The study recruited approximately 40,000 women in three birth cohorts, 1973-1978, 1946-1951 and 1921-1926, who have since been followed up approximately every three years using self-report surveys. Six surveys have been completed to date. This review aims to describe the changes in weight and weight status over time in the three ALSWH cohorts, and to review and summarise the published findings to date relating to the determinants and health consequences of weight gain, overweight and obesity. Future plans for the ALSWH include on-going surveys for all cohorts, with a seventh survey in 2013-2015, and establishment of a new cohort of women born in 1990-1995, which is currently being recruited.

Keywords

Australian Longitudinal Study on Women's Health, body mass index, health outcomes, determinants, overweight, obesity

Introduction

Recent estimates suggest that 35.3% of adult Australians are overweight and a further 27.5% are obese [1]. Hence almost two thirds of adult Australians are at increased risk of developing a range of chronic health conditions, such as cardiovascular disease, type 2 diabetes, arthritis, depression and some cancers [2]. A recent report ranked high body mass index (BMI) as the leading risk factor contributing to overall Burden of Disease in Australasia [3] and the World Health Organisation estimates that non-communicable diseases, many of which are associated with overweight and obesity, account for approximately 90% of all Australian deaths [4]. Managing the health consequences of overweight and obesity was estimated to cost approximately $56.6 billion annually in both direct and indirect health costs in 2010 [5] and the prevalence of overweight and obesity continues to increase in Australia, with a 6.5% increase since 1995 [1].

Weight gain occurs when there is a state of positive energy balance, that is, when energy intake exceeds energy expenditure, resulting in energy storage. Conversely, weight maintenance occurs when the body is in a state of energy balance, when energy intake and energy expenditure are balanced over a period of time, resulting in minimal energy storage. [6]. The determinants of weight change and more specifically, weight gain, primarily include those that influence energy intake and energy expenditure. These determinants are however multi-faceted and reflect a complex interaction of biological, behavioral and environmental factors. In turn, the health consequences of obesity are far reaching, influencing both physical and mental health and well-being.

Given the personal, social, health, societal and economic costs of overweight and obesity, research investigating the determinants and consequences of unhealthy weight and weight gain is of particular importance. The Australian Longitudinal Study on Women's Health (ALSWH) is a prospective study of women's health that commenced in Australia in 1996, with the aim of identifying factors that determine good health and those that cause ill-health in women across the lifespan. The study provides a unique opportunity to examine changes in health over time in three generations of Australian women. To date, more than 400 scientific papers have been

published from the ALSWH, and many of these have investigated weight change, overweight and obesity and their determinants and health consequences.

The aim of this review is to describe changes in weight and weight status over time in the three ALSWH cohorts, and to review and summarise findings relating to the determinants and health consequences of weight gain, overweight and obesity.

Australian Longitudinal Study on Women's Health

The Australian Longitudinal Study on Women's Health (ALWSH) is a prospective, population based survey, funded by the Australian Government Department of Health and Ageing. The study involves three large, nationally representative birth cohorts of Australian women, born in 1973-78, 1946-1951 and 1921-1926. Approximately 110,000 women across the three cohorts were randomly selected from the Medicare database and more than 40,000 completed the first baseline survey in 1996, when they were aged 18-23, 45-50 and 70-75 years, respectively. Participants have since completed self-report mailed surveys every three years over 16 years, with six surveys of each cohort now completed. The schedule of ALSWH surveys completed to date, the age in years and the number of participants at each survey is presented in Table I. The main reasons for declines in numbers of participants are: loss to follow-up between surveys 1 and 2 for the youngest women, who were at a highly mobile stage of life then; and deaths and withdrawals due to increasing frailty among the oldest cohort who are now in their 80s. The full surveys are available online (www.alswh.org.au).

Table I Schedule of surveys for the Australian Longitudinal Study on Women's Health and the age in years and number of participants at each survey, to 2012 [7]

Survey	**1973-78 cohort**	**1946-51 cohort**	**1921-26 cohort**
Survey 1	1996 Age 18-23 N=14247	1996 Age 45-50 N=13715	1996 Age 70-75 N=12432
Survey 2	2000 Age 22-27 N=9688	1998 Age 47-52 N=12338	1999 Age 73-78 N=10434
Survey 3	2003 Age 25-30 N=9081	2001 Age 50-55 N=11226	2002 Age 76-81 N=8647
Survey 4	2006 Age 28-33 N=9145	2004 Age 53-58 N=10905	2005 Age 79-84 N=7158
Survey 5	2009 Age 31-36 N=8200	2007 Age 56-61 N=10638	2008 Age 82-87 N=5561
Survey 6	2012 Age 34-39 N=7231	2010 Age 59-64 N=10011	2011 Age 85-90 N=3672

Surveys

Each ALSWH survey includes questions on physical and mental health, lifestyle, use of health services and health outcomes. Questions on height and weight have been included in each ALSWH survey to date, with responses used to calculate BMI (weight /height^2), which is categorized as: underweight, <18.50; healthy weight, 18.50-24.99; overweight, 25.00-29.99; or obese ≥ 30.00, in line with WHO recommendations [8]. A validation study with 159 women in the 1946-1951 cohort found that agreement for correct classification of BMI ranged from 73 to 94%

(kappa=0.81), and that both height and weight tended to be underestimated, with a mean difference of 0.67 cm [95% confidence interval (CI) 0.26-1.08 cm] and 0.95 kg (95% CI 0.44-1.47 kg), respectively [9].

Findings from ALSWH: Weight and weight status in three cohorts, over 16 years.

In the 1973-1978 and 1946-1951 cohorts, the overall trend over 14-16 years was for women to gain weight, illustrating the effect of age on weight gain in these two cohorts. However, the greatest weight gain was seen among women in the 1973-1978 cohort; at survey 1 (age 18-23), average weight was 62.5 kg [standard deviation (SD) 12.7 kg] and by survey 6 (age 34-39), this had increased to 72.6 kg (SD 17.9 kg) (Figure I). Average annual weight gain between successive surveys in the younger cohort was 636, 743, 615, 608 and 376 g/year between surveys 1 to 6, respectively. As a result, average weight at age 34-39 was higher than the baseline weight of the mid-age cohort, who were aged 45-50 years when the study began in 1996 (see Figure I). Although it is not yet possible to confirm the exact generational or cohort effect, as the ages of these two cohorts do not yet coincide, we predict that the average weight of the 1973-78 cohort will be approximately 8 kg greater than the weight of the 1946-51 cohort as the younger women move through mid-age, if their current weight gain trajectory continues.

At survey 1, the majority of the younger cohort was classified as being in the healthy BMI weight range (68%), with a smaller proportion underweight (10%) and about one fifth overweight or obese (21%). At each survey, the proportion of underweight and healthy weight women decreased, while the proportions of overweight and obese women increased, resulting in approximately half the sample being overweight or obese at survey 6 (49%). The proportions of women in each BMI category across all surveys are presented in Figure II (Panel A).

Women in the 1946-1951 cohort demonstrated a similar trend for weight gain from survey 1 to survey 6. At survey 1 (age 45-50 years) average weight was 68.7 kg (SD 14.2 kg) and at survey 6 (age 59-64 years) average weight was 73.2 kg (SD 15.4 kg) (Figure I). However, compared with the 1973-1978 cohort, the rate of weight gain

was slower, with average annual weight gain between surveys in this cohort of 278, 474, 332, 171 and 204 g/year from survey 1 to 6, respectively. Notably, the women in this cohort started the study with a much higher average weight (68.7 kg SD 14.2) than those in the 1973-1978 cohort (age 18-23, 62.5 kg, SD 12.7 kg) in 1996, but by survey 6 at age 59-64, they weighed only 0.6 kg more than the younger cohort who were aged 34-39 by then (see Figure I). At survey 1 approximately half the 1946-1951 cohort were considered to be in the healthy BMI weight range (51%) and half were overweight or obese (47%), with a very small proportion underweight (2%). Across the surveys, there was a gradual decrease in the proportion of healthy weight women and an increase in the proportions classified as overweight or obese. By survey 6, the majority of the cohort was considered overweight or obese (62%). The proportions of women in each BMI category in the 1946-1951 cohort across all surveys are presented in Figure II (Panel B).

Comparatively, in the 1921-1926 cohort the trend was for a decrease in weight. At survey 1 (age 70-75), average weight was 65.9 kg (SD 11.8 kg). By survey 6, (85-90 years), average weight was 62.8 kg (SD 13.5 kg) reflecting a gradual decline between surveys (average annual weight change -171, -166, -364, -418 and -575 g/year between surveys 1 to 6, respectively) (Figure I). Although their average weight was lower, women in the 1921-1926 cohort started the study with a similar BMI profile to that seen in the 1946-1951 cohort, with half the women in the healthy weight range (50%), a very small proportion underweight (2%), and the remaining women overweight or obese (46%). The majority were categorised as overweight (33%). The proportion of women in each BMI category changed very little over the course of the six surveys; this reflects the age-related loss in height which accompanied an overall decrease in weight, resulting no net effect on BMI. Additionally, loss-to-follow-up due to illness or death means there is a ‘healthy survivor’ effect in this cohort. The proportions of women in each BMI category in the 1921-1926 cohort across all surveys are presented in Figure II (Panel C).

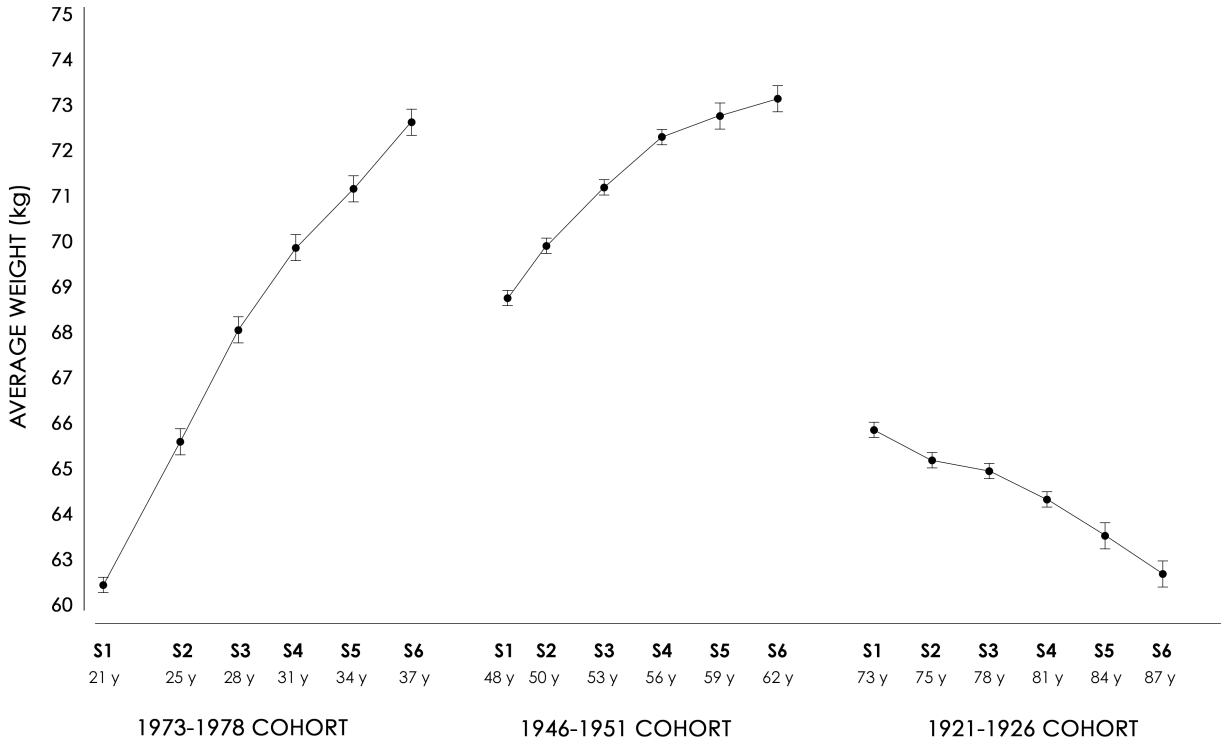

Fig. I: Average weight (kg ±1 standard error) of women in the 1973-1978, 1946 – 1951 and 1921-26 cohorts at each survey, with age to the nearest year for each survey. Sample sizes for each cohort, at each survey, are shown in Table I.

Note: S=Survey

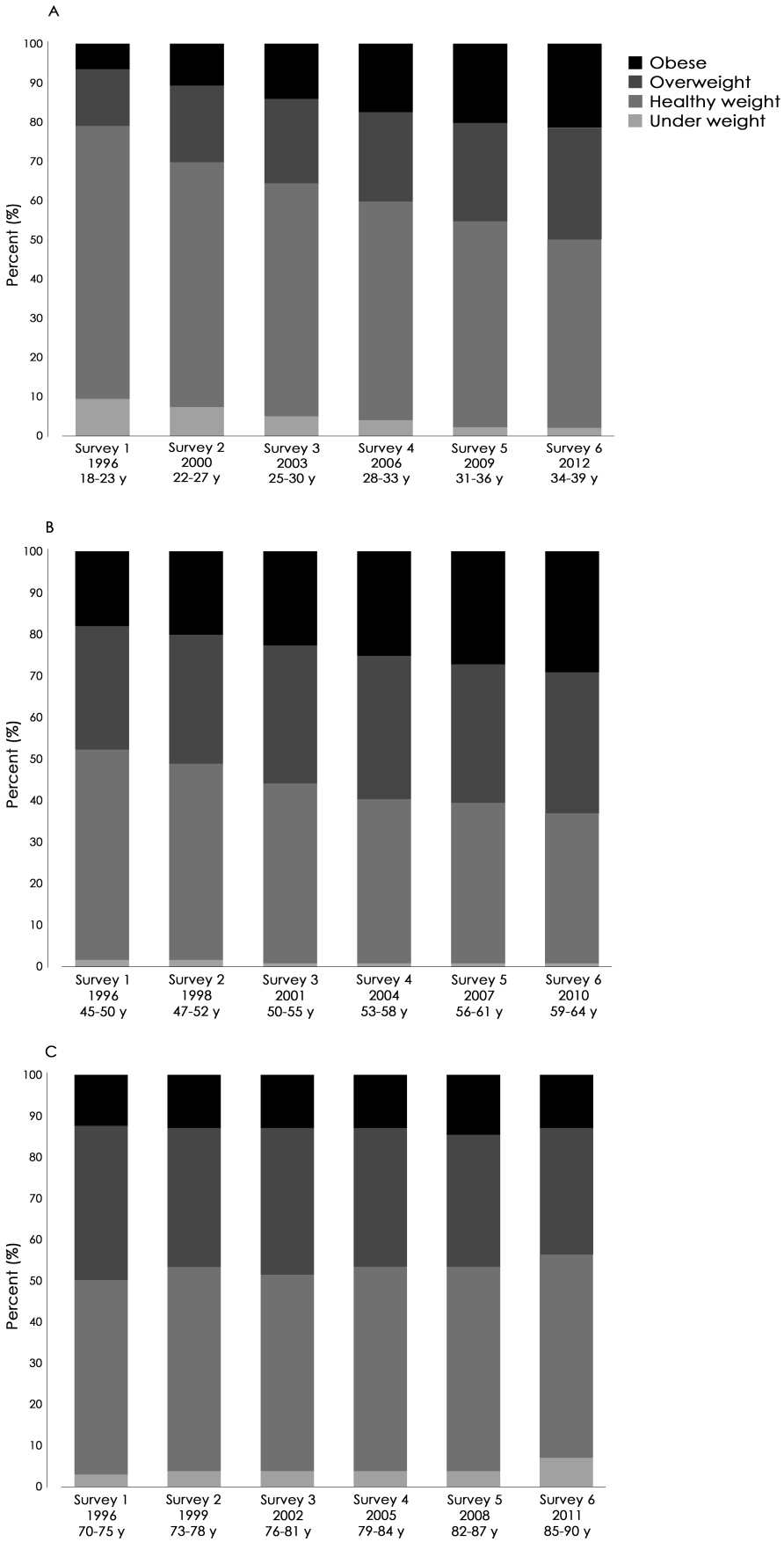

Fig. II: Proportions of women in each BMI category at each survey for the 1973-1978 (Panel A), 1946-1951 (Panel B) and 1921-1926 (Panel C) cohorts. Sample sizes for each cohort, at each survey, are shown in Table I.

Determinants and weight-related health outcomes.

Published studies of the determinants of weight and weight change, and their health consequences were identified through an electronic search of the ALSWH internal database (13 June 2013) using the search terms body mass index, weight, weight gain or body weight. This search yielded 72 potential studies that were then retrieved in full text and screened for inclusion criteria. Studies were selected for inclusion if they included: (1) longitudinal analyses; (2) a weight status or weight change variable; and (3) a health determinant or health outcome variable. Methodological and review papers, those with only cross-sectional analyses (N=9), and those which included BMI only as a covariate in the analyses, were excluded. Twenty-nine studies were included and 43 were excluded, mostly because they only included BMI as a covariate in the analyses.

The included studies were approximately evenly distributed between cohorts, with 10 studies of data from the 1973-1978 cohort, and nine each from the 1946-1951 and 1921-1926 cohorts. One study addressed relationships between BMI and the incidence of chronic conditions across all three cohorts. Approximately half the studies addressed determinants and half focused on self-reported health outcomes in the 1973-1978 and 1946-1951 cohorts. However in the 1921-1926 cohort, all the papers focused on health outcomes. The findings of the included papers are summarised below by cohort.

1973-1978 Cohort

Six papers focused on the sociodemographic, psychological, and behavioural determinants of weight and weight gain in the 1973-1978 cohort. From a sociodemographic perspective, age, education, employment status, marital status and parity were shown to influence weight change over time. For example, women who were younger at the baseline survey (18 years of age) gained weight approximately 200g/year faster than the older women in the cohort (23 years) [10]. Having a partner and/or baby markedly influence weight gain; women in this cohort who were partnered (only) or partnered and had their first baby, gained 1.8 and 4.0 kg more respectively, than unpartnered, childless women over 10 years. Subsequent babies did not have as much effect on weight gain [10].

The ALSWH findings also show associations between education and occupation and weight. For example, women with higher levels of education [10, 11] and those who worked part-time [12, 10], were less likely to gain weight than women with lower education, or who worked full-time, respectively. In addition to their own education, the ALSWH findings also show that women whose

mothers had a higher education were also less likely to gain weight than those with lower educated mothers. Additionally, women who maintained their weight within 5% over a four year period were more likely to be in managerial or professional occupations, never married and currently studying, than those who did not maintain their weight [13].

Several papers demonstrate the behavioral determinants of weight change, including physical activity, sedentary behavior, energy intake and smoking. For example, women who increased their sitting time [14, 10] or energy intake [10] or who quit smoking [10] gained more weight over time, while women who increased their physical activity between surveys [10] gained less weight. Weight maintainers were also likely to spend less time sitting and consumed less takeaway food than women who gained weight [13].

A few ALSWH studies also address the psychological determinants of weight change. For example, Ball and colleagues [15] found that women who reported that they "never put on weight, no matter what" were less likely to gain weight over a two year period than other women. Women who placed importance on being physically active, and who generally paid more attention to weight, physical activity and dietary intake, and who did not let friends sabotage their activity efforts, also gained less weight than others in the cohort [15].

Studies investigating the longitudinal associations between BMI and health outcomes in the 1973-1978 cohort primarily focus on chronic conditions, psychological health and women's health issues. Development of symptoms and conditions was consistently higher for all health outcomes in overweight and obese women. For example, over a seven year period, women who were overweight were significantly more likely to develop hypertension and asthma and those who were obese were more likely to develop hypertension, diabetes [16] and depressive symptoms than their healthy weight peers [17]. Women who were overweight or obese were also more likely to report development of gestational diabetes mellitus [18] and polycystic ovary syndrome [19] over three and 10 years, respectively, than women who were in the healthy weight range.

1946-1951 Cohort

In comparison with the 1973-1978 cohort, fewer studies investigate the sociodemographic determinants of weight change in the mid-age cohort. Two studies focus on the influence of social class and employment. They found that socially disadvantaged women (described as working class) [20] and women who worked very long hours [21] gained significantly more weight over two years than women who were socially advantaged (middle/upper class) or who worked shorter hours.

The behavioral determinants of weight change in the 1946-1951 cohorts are similar to those described for the 1973-1978 cohort, with lower levels of physical activity, higher energy intake and quitting smoking associated with greater five year weight gain [22]. The ALSWH researchers have however raised an important question about the influence of sitting time on weight change. Although a 2005 paper found that higher sitting time was associated with five year weight gain [22], this relationship was not confirmed in prospective analyses, which concluded that women with higher BMI sat more than their healthy weight counterparts [23]. Additional papers have shown that women who used behavioural weight control practices, including a combination of decreasing energy intake, using a commercial weight loss programme and exercise, prevent weight gain [24], but that socially disadvantaged women were more likely to use potentially harmful weight control practices, for example laxatives, diuretics, diet pills, fasting or smoking [20]. One paper that examined the health determinants of weight change in the 1946-1951 cohort found that women transitioning into menopause were more likely to gain more than 5 kg over five years than pre-menopausal women [22]. Finally, with respect to mental health, a recent study has reported that depression predicted increased risk of weight gain, but that weight change (either weight gain or loss) was not associated with increased risk of depression [25].

Studies of the health consequences of BMI and weight gain in the 1946-1951 cohort focus on chronic conditions, with similar findings to those in the 1973-1978 cohort. Overweight and obese women were more likely to develop hypertension, heart disease, asthma [16] and diabetes [16, 26], and to report hysterectomy, than healthy weight women [27]. Overall, women who gained at least 2.25 kg over two years reported poorer physical and mental well-being [28] and those who reported more than 5kg weight gain over three years also reported more menopausal symptoms [29].

1921-1926 Cohort

To date there are no studies of the determinants of weight status or weight change in the 1921-1926 cohort, highlighting this as a future area of analysis for ALSWH researchers. However, a number of studies investigate associations between BMI, weight change and several health outcomes, including physical functioning, chronic conditions, acute adverse health events and mortality.

In the older cohort, overweight and obesity were associated with increased risk of a number of chronic conditions including diabetes mellitus [16, 30, 31], hypertension [16, 30], heart disease [30] and asthma [16]. Our work has also demonstrated associations between weight and the increased likelihood of developing foot problems [32], arthritis [16] and incontinence [33]. Overweight or

obese women were also more likely to report declining physical functioning [34, 35] and linked data showed increased incidence of acute adverse health events, including hospital admissions [30] and stroke [35]. In the entire body of work on weight and health in this cohort of women, the only positive health outcome of high BMI was reduced risk of osteoporosis [28]. This is because the increased load on the skeleton of high BMI individuals promotes higher bone mineral density [36].

The ALSWH researchers have demonstrated a 'U" shaped relationship between BMI and mortality, with higher risk of death in both underweight and obese women [30, 37, 38]. The optimal BMI for health outcomes and mortality is around 25-27 kg/m^2 in the older ALSWH cohort [28]. This work highlights that generic adult BMI cut points may not be appropriate in predicting the healthy weight range in older adults [30]. Age-specific cut points for older adults have been recommended, however they have yet to be adopted at an organisational level (e.g., by the World Health Organisation).

Strengths and limitations

A primary strength of the ALSWH is that we are simultaneously studying three cohorts of adult women, defined by birth years, as they age during the same calendar period. This allows us to better understand the age, period and cohort effects on temporal trends and to predict future trends, as illustrated by the reporting of different trajectories of weight change in this review. The main limitation of the study is that all data collected are self-reported, including height and weight, and there are no objective measures of anthropometry, such as body weight, height or body fat percentage. Another limitation is that while Australia is a country of many nationalities, the majority of the women in the three cohorts are from English speaking or European backgrounds, with some representation in the younger cohort of women from Asia. This means that we are unable to draw out differences in weight change, its determinants and outcomes, based on ethnicity.

Conclusions

Findings from the Australian Longitudinal Study on Women's Health highlight the fact that, in younger and mid-age Australian women, there is an overall trend of continuing weight gain and increasing levels of overweight and obesity. The study provides a valuable opportunity to gain insight into the determinants and health consequences of these trends. The results of this review suggest that, while the determinants of weight gain relate to energy intake and expenditure, the behaviours that explain energy balance, (i.e., eating, sitting and moving), are strongly determined

by lifestage, social circumstances, and occupation, as well as by psychological attributes such as attitudes to activity and diet. In the context of contemporary Australian society, it is likely that the key events implicated here would be similar to those seen in most Western developed countries.

Although many of the ALSWH participants maintained their weight over time, and others showed fluctuations in weight gain and weight loss, the overall trend was an increase in weight over time. Based on the ALSWH findings, it is recommended that women should maintain their weight within 2 kg across the adult life-span. This recommendation is based on the premise that once weight is gained, it is difficult to lose [6] and there are increasing levels of poor health outcomes with overweight and obesity. Although the idea of making consistent and sustained 'small changes' to energy intake and expenditure has merit [22, 39], more evidence based strategies for preventing weight gain and maintaining body weight in the healthy range are required. [39]

Closing the energy gap and reducing the trend for weight gain is of primary importance, and small changes could potentially result in large gains in health outcomes. In Australia, obesity has been defined as a National Health Priority Area since 2006 [40] and has been included in the most recent Strategic Research Priorities through the challenge of 'promoting population health and wellbeing' [41]. We are unable to yet see any effects of these actions in our data. Future plans for the ALSWH include on-going surveys of all three cohorts, as well as establishment of a new cohort of women born in 1990-1995, which is currently being recruited. It will be interesting to see whether the trend of increasing levels of overweight and obesity continues into the next generation of Australian women, or whether the social marketing and policy responses to this national health problem start to prevent weight gain, and stem increasing levels of overweight and obesity in our population.

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